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The Impact of Technological Change on Corporate and R & D Management

A Survey

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THE RELATIONSHIP between technology and a company's competitive strength is gaining ever-wider recognition. "Technological innovation will dictate competitive advantage and disadvantage." This statement by a senior executive of a U.S. construction materials manufacturer is typical of many elicited in the course of recent Conference Board programs concerned with technology and its management. Similarly, a recent survey report of European chief executives found that "...technology represents an opportunity, a threat, a tool--but not an end in itself. Yet its impact on competitive position—at both corporate and national levels—can be so profound that it must be thoroughly understood and managed, if unacceptable risks are not to be run."[1]

What is perhaps less clearly perceived is how technological change has affected and will affect the *management* of the company as a whole and, more specifically, its research and development resources. It is this relationship that the present survey, reflecting the experiences and expectations of 242 executives in 15 highly industrialized nations, addresses.

The principal findings are that, in the next one to three years, developments in the technological environment will have broad but uneven effects on management in general and the research and development function in particular, and that in the realm of R&D, these effects will be greater than they were in the year before the survey was conducted (see the italicized passages on page 8)[2].

[1]Booz, Allen & Hamilton Inc., "Management and Technology: A Survey of European Chief Executives," 1984, p. 1.

[2]That environmental developments in the near term will have greater consequences for management than these developments have had in the recent past is a central point of a Conference Board study on the regulation of international data transmission across national borders. See James R. Basche, Jr., *Regulating International Data Transmission: The Impact on Managing International Business*. The Conference Board, Report No. 852, 1984.

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The Survey Participants

Conducted in the early months in 1984, the survey drew responses from 242 senior executives—the great majority of them in charge of their companies' technological programs—of leading firms in the United States, Europe and Japan. Most of these firms have annual revenues or assets in the range of U.S. $100 million to $10 billion; 22 are larger and four are smaller. The participating companies are further described in the table below.

Characteristics of Participating Companies[1]

Dominant Function	*Number of Companies with Headquarters in U.S.A.*	*outside U.S.A.[2]*	*Total*
Research, engineering, manufacturing	91	20	111
Marketing	25	3	28
Utilities	19	1	20
Finance	3	5	8
Transportation	5	1	6
Other services	6	2	8
Several functions	40	10	50
Totals	189	42	231

Diversity and Complexity	
Set of related businesses	155
Set of unrelated businesses	36
A single business	44
Total	235

[1]None of the totals equals 242 because of incomplete response to the questions that generated these data.
[2]One Japanese company; the others are European.

Significant Developments in the Technological Environment

Table 1 (see page 4) presents data on the developments in the technological environment that respondents chose as likely to affect how their companies will be managed in the next one to three years. The "first" and "second" rankings determined the order of the table, although process production technology had fewer mentions overall than R&D, administration, and mechanical production technology.

The salient findings are:

- Perhaps not surprisingly, in view of the composition of the survey participants, technology used in R&D management has more "most important" and "second most important" votes than technology used in any other field. From the same perspective, technology used in process production is next.
- In terms of total mentions, on the other hand, technology used in administration leads the list, with technology used in R&D a close second; well behind are technology used in mechanical production and in process production. Indeed, except for distribution, none of the fields of application of technology has the same rank in number of mentions and in number of times it is judged as first or second in importance. The full comparison:

Field of Application	Frequency of Mention	Frequency of Mention as First or Second in Importance
Administration	1	3
Research & Development	2	1
Mechanical Production	3	4
Process Production	4	2
Marketing	5	6
Distribution	7	7
Other	6	5

Table No. 1: Major Technological Developments Expected to Affect Company Management in the Next One to Three Years

Technology Used In	Ranking by Relative Importance Number of Mentions: Top Range (1st or 2nd)	Middle Range (3rd or 4th)	Low Range (5th, 6th or 7th)	Total Mentions
Research and Development (e.g., computer-aided design, instrumentation)	134	62	9	205
Process Production (e.g., biotechnology, conversion of older industries from batch to process production)	95	44	13	152
Administration (e.g., word processing, data processing, material requirements, planning, documentation)	87	90	31	208
Mechanical Production (e.g., machining, forming, robotics, testing)	86	49	20	155
Marketing (e.g., telemarketing, electronic "yellow pages," field servicing)	36	61	30	127
Distribution (e.g., warehousing, transportation)	22	53	33	108
Other functions	28	4	2	34

• When the "upper" and "middle" ranges are combined (ranks "1" to "4"), there is again a slightly different order. Since these functions were described on a questionnaire and the respondents were asked to rank them *all*, the best summary statement may be that the first four items listed in the tabulation and in Table 1 are judged to be more likely to have a significant impact in the short-term future.

Chi-square tests were run on responses to this and subsequent questions to glean clues as to meaningful differences between U.S. and non-U.S. companies and among companies grouped by diversity and complexity.[3] At the .05 level of significance:

Area of Technological Development	Sample Results: Variable Found to Have Significant Difference	Companies Expecting to Have Managing Affected to a Greater Degree	Companies Expecting to Have Managing Affected to a Lesser Degree
R&D activities	Headquarters location	U.S.	Non-U.S.
Mechanical production	Diversity and complexity	Unrelated businesses	Single businesses
Process production	Diversity and complexity	——	Single businesses
Distribution	Diversity and complexity	Single businesses	Unrelated businesses
Administration	Diversity and complexity	Single businesses	Single businesses

[3]A chi-square test entails comparing expected or computed frequencies with observed or actual frequencies of two variables to see whether discrepancies between expected and observed frequencies are greater than might be expected by chance.

Perspectives

A number of executives offered perspectives on developments in technology in general and its application or emphasis in their own companies in particular. Several pointed out that their firms are already making extensive use of technology in one or another function (R&D, production, marketing, etc.). Others emphasized the consequences of technology for marketing or for their customers.

For instance:

"Process-production technology is primarily a marketing opportunity, not an in-house one."

—A U.S. industrial products manufacturer

"We see technological developments in the *use* of many of our products."

—A Dutch manufacturer

"Impact of technology on the businesses we serve, which can affect products we sell them."

—A U.S. chemical and drug manufacturer

"Technology leading to advanced performance of the product or products, with new capabilities and potentially new markets."

—A U.S. aerospace manufacturer

"We expect more direct contact with customers."

—A U.S. chemical company

"In the retail portion of our business, the development of electronic scanning systems will lead to significant change."

—A Danish manufacturer and distributor

"Technology to develop new products, which could create new markets."

—A Japanese steel manufacturer

"R&D must develop products that are based on technology exhibiting a customer benefit."

—A U.S. building material manufacturer

For still others, materials and products stood at the forefront of concern:

"Reduction in commodity products and development and increasing activity in special chemicals."

—A U.S. petrochemical company

"New or improved materials in their applications (i.e., ceramics in engines, engineering plastics, conductive polymers) requiring substantially different resource requirements and R&D approaches."

—A U.S. industrial equipment manufacturer

"We attach importance to scientific developments in catalysis material."

—A U.S. petroleum refiner

Another theme in these obiter dicta was the integrated or interactive effects of new technology:

"The interaction of design and manufacturing technology—the integration of CAD and CAM."

—A U.S. farm equipment manufacturer

"Integration of several of these areas (R&D, production, etc.), in plants fully automated from initial design to inspection and field service."

—A diversified U.S. manufacturer

"Joint R&D between two or more companies, either in different geographical areas or at different levels in the chain."

—A U.S. chemical manufacturer

Then there were variegated comments on the emphasis of technological programs sponsored by individual companies:

"Speed and accuracy most important in R&D-related technology."

—A U.S. electronics and communications company

"R&D technology is critical to improve design and management of production."

—A U.S. aerospace manufacturer

"In mechanical production, quality is the main objective."

—A U.S. electronics and communications company

"Application of mechanical production necessary for increased productivity and less reliance on skilled personnel."

—A U.S. aerospace manufacturer

"In process production technology, there are two concepts: new types of industry and revitalization of older plants. Both would be important."

—A diversified U.S. manufacturer

"We have undertaken a program of evaluating process production technology in our pilot plants, and then to institute a program to give the company a leading edge in technology."

—A U.S. drug company

"Much effort is needed to update existing power plants to 1980's technology."

—A U.S. utility

"The use of technology in administration is a result of management commitment to improve productivity."

—A U.S. industrial products manufacturer

"An important thrust is in environmental matters: the control and disposal of toxic substances and hazardous wastes."

—A U.S. paint manufacturer

One executive stressed the indisputably vital role of corporate leadership with respect to the adoption of new technology.[4] Noting that his company would have a new chief executive officer in 1985, he said that "his view of high technology" will prevail. And the respondent added: "If we are acquired by another company, we shall have another new view of high technology."

[4]This point was stressed by contributions to two recent Conference Board reports: James K. Brown (ed.), *Research and Development: Key Issues for Management*, Report 842, 1983; and James K. Brown (ed.), *Manufacturing: New Concepts and New Technology to Meet New Competition*, Report 844, 1984.

Not all the survey participants are believers in the precept that technology will exert a strong influence on how companies conduct, or will conduct, their affairs. Thus, a diversified U.S. consumer products manufacturer observed: "I do not see technology affecting *how* we manage the business in the next three years."

Specific Applications

In terms of specific applications, some of the surveyed executives gave examples other than those given in Table 1.

In R&D: expansion of data sources for new ideas; automation of laboratory experimentation and data manipulation; color matching by computer.

In process production: development of new combustion processes (e.g., pressurized fluidized beds); environmental clean-up processes; heat and power conservation; computer-controlled chemical plants; heavy oil processing; new polymers; new catalysts.

In administration: electronic mail—internal, external, international; increased use of personal computers (enabling "a major share of professional staff to use PC terminals from home," a British executive opines).

In mechanical production: testing; automatic defect rejection; computer networking data-base management; group technology.

One Impact of Technology on the Judiciary

"There is such an abundance of precedents in so many areas, so many hundreds of thousands of reported cases, all retrievable through computerized research tools, that a great many decisions at every level of the judicial system are, in a sense, chosen rather than determined."

—Judge Richard A. Posner
U.S. Court of Appeals
for the Seventh Circuit;
cited in Betty Bock and others,
The Future of Antitrust
Conference Board Research
Bulletin No. 163, 1984.

In marketing: electronic medical education; explosion in use of credit or debit cards in Europe; marketing and customer information management.

In distribution: working capital (particularly inventory) management; automation of order preparation and selection; local control of an electrical utility's distribution facilities.

Other applications: power generation, transmission and distribution; exploration for oil and gas; scheduling; inventory control; purchasing.

Effects of Changes in the Technological Environment on R&D Management

Table 2 shows the relative strategic importance attributed by survey participants to the several elements of R&D management likely to be affected by changes in the technological environment in the next one to three years. As can be seen, changes in planning procedures and organizational linkages lead the list, with top management's efforts to spur innovation a respectable second.

In contemplating planning-organizational and human-resources areas of change, it is useful to look ahead to Table 3. Note that some of the elements of changes in planning procedures and organizational linkages center on people—for instance, greater involvement of technology managers in setting corporate direction and increasing involvement of R&D people in corporate planning. Thus broadened in scope, the human side of R&D management may be more significant than the barebones data in Table 2 indicate. Many contributors to recent Conference Board publications on R&D management and the adaptation of modern manufacturing technology underscored the importance of people issues. (See footnote 4, page 5.)

In this ranking of areas of change by strategic importance, there was no meaningful difference among companies grouped by diversity and complexity. As for headquarters location, U.S.-based companies were less likely than non-U.S. companies to choose as more important (first or second rank) the general issue of "human resources aspects" of R&D management.

Changes in Planning Procedures and Organizational Linkages

Table 3 depicts the contributors' experiences in the last year, and their expectations for the next one to three years, with respect to the impact of changes in the technological environment on various aspects of planning procedure and organizational linkages. The salient findings:

- Although changes in planning procedures and organization linkages received more first and second rankings in terms of strategic importance than any other sector of change (Table 2), no specific planning-organizational

Table No. 2: Relative Strategic Importance of R&D Management Changes

Area of Change	Ranking by Relative Importance Number of Mentions		
	Top Range (1st or 2nd)	*Middle Range (3rd or 4th)*	*Low Range (5th or 6th)*
Planning procedures and organization linkages	148	61	28
Top management's efforts to spur innovation	131	66	39
Internal aspects of R&D management	74	106	51
Human resource aspects of R&D management	73	99	59
Financing of R&D	43	86	99
External aspects of R&D management	16	53	157

Table No. 3: Impact of Technological Change on Planning Procedures and Organizational Linkages (Responses in Percent)

Area of Change	Strategic Importance of Change				Shifts in Impact		
	In past 12 months		*In next 1-3 years*				
	Major	*Minor*	*Major*	*Minor*	*Up*	*Down*	*No Shift*
Greater involvement of technology managers in setting corporate direction	31	56	59	36	38	3	59
Increasing influence of technology on corporate strategy	41	50	68	29	33	2	65
Increasing formal technological forecasting	9	51	24	58	35	1	64
Improving the linkage of technology to other business functions	35	53	61	35	35	3	62
Raising the stature of technology management with respect to other business functions	18	58	39	48	32	3	65
Increasing involvement of R&D people in the corporate planning process	24	56	46	43	32	2	66
Increased involvement of the CEO in the technological planning process	24	50	35	51	24	2	74

Other planning-administration linkage changes volunteered by the respondents were: broader analysis and application of technological strengths; fitting technology to serve the markets; launching a formal research-planning group; marketing involvement in R&D planning and in strategic planning; technology assessment and monitoring; placing former R&D personnel into operating positions to enhance technology transfer from labs to practical application; and MBO programs, automatic inventory control, quality assurance management.

change triggered a substantial strategic reaction in more than 41 percent of the companies in the 12 months before the survey was conducted.

• A majority of the respondents expect three changes to have major strategic importance in the next one to three years: increasing influence of technology on corporate strategy (68 percent); improving the linkage of technology to other business functions (61 percent); and greater involvement of technology managers in setting corporate direction (59 percent).

• *For each aspect of planning-organization, there was a higher percentage of "major" votes for the next one to three years than for the last twelve months. This holds true for every item in the remaining tables, with a single exception (second item, Table 7).*

• "No shift in emphasis" was the predominant outlook, accounting for over 50 percent of the judgments for each activity listed in Tables 3 to 8. *But where there were shifts in emphasis (counting up or down all changes between the past year and the next one to three years) they were overwhelmingly in the upward direction (e.g., minor to major, none to minor, none to major) in this and subsequent tables.* (Again, the sole exception is the second activity in Table 7.) In fact, downward shifts in emphasis did not exceed 11 percent of responses in any table, and were more typically less than 5 percent.

Technology managers in U.S. companies were more likely than their counterparts in non-U.S. companies to have become more involved in setting corporate direction in the year before the survey was conducted. Expectations for the next one to three years showed these statistically significant differences among groups of companies:[1]

Area of Change	Sample Results: Variables Found to Have Significant Difference	Companies More Likely to Make Changes	Companies Less Likely to Make Changes
Greater involvement of technology managers in setting corporate direction	Headquarters location	U.S.	Non-U.S.
Increasing formal technological forecasting	Headquarters location	U.S.	Non-U.S.
Raising stature of technology management with respect to other business functions	Headquarters location	U.S.	Non-U.S.
Increased involvement of CEO in the technological planning process	Headquarters location	U.S.	Non-U.S.

[1].05 level or lower, chi-square test.

Top Management's Efforts to Spur Innovation

Table 4 summarizes results and expectations regarding the influence of technological change on top management's efforts to spur innovation. In the previous year, such change did not have major strategic effects on any of the listed efforts in as many as a third of the companies, nor is it anticipated to do so in the next one to three years in as many as half the companies ("increased emphasis on internal growth" was judged "major" by 48 percent).

In the array of firms by diversity and complexity, single-business companies were *less* likely to have bestowed greater recognition on, and made efforts to motivate, internal entrepreneurs, in the past year; and unrelated-business companies (conglomerates) were *more* likely to have sought to capitalize on governmental programs to spur innovation, and to do so in the next one to three years.

Financing R&D

Technological change has not had, nor is it likely to have, an influence of major strategic importance on R&D financing in most firms represented in the survey, as Table 5 (see page 10) indicates. The element of financing on which it has, and is expected to have, a significant impact in the largest number of companies is absolute increases for capital equipment used by R&D personnel, followed by increases in *relative* R&D expenditures.

The Human Resources Side of R&D Management

In the next one to three years a majority of the respondents foresee that technological change will result in changes of major strategic importance in two closely related aspects of human-resources management: efforts to improve individual performance and upgrading the quality of the R&D staff (Table 6, page 11). When the companies were

(text continued on page 12)

Table No. 4: Impact of Technological Change on Top Management Efforts to Spur Innovation (Responses in Percent)

	Strategic Importance of Change						
	In past 12 months		*In next 1-3 years*		*Shifts in Impact*		
Area of Change	*Major*	*Minor*	*Major*	*Minor*	*Up*	*Down*	*No Shift*
Greater recognition and motivation of internal entrepreneurs	22	53	44	46	38	2	60
Simplification of traditional procedures and practices	16	55	30	55	30	4	66
Increased emphasis on internal growth	30	48	48	39	29	4	67
More efforts to capitalize on governmental programs to spur innovation[1]	11	36	17	38	16	2	82

[1]See box on page 10 for specific programs mentioned.

Other Management Efforts to Spur Innovation

Survey participants reported a plethora of efforts their companies have undertaken, or will undertake, to spur innovation (other than those suggested to them on the questionnaire and summarized in Table 4) with internal thrusts much more frequently mentioned than external thrusts. Taken as whole, these initiatives may serve as a useful check list.

Internal Thrusts

Organizational changes: Formation of high-level technology or innovation committees, institution of a "dedicated diversification group," decentralization of decision making, better integration of research into other functions or units.

Motivational efforts: More recognition of and rewards for innovators, enhanced teamwork among researchers, gainsharing (programs like the Scanlan Plan that link extra compensation to productivity improvements).

Management directional efforts: Better administration, better guidance of the innovation process, use of deadlines, employment of consultants, seeking internal entrepreneurs, new practices aimed at doing more with less, changed (presumably improved) management style.

Investment: Expansion of laboratory facilities, longer-term funding, provision of seed money.

Educational initiatives: Making technical innovators more aware of business and customer requirements, instilling greater understanding of technology throughout the organization.

External Thrusts

Obtaining technology developed by others—by acquisitions, licensings, venture-capital programs.

Participating (more fully) in collaborative efforts: joint ventures, industrywide cooperative undertakings, university-industry programs.

* * * *

Some of these changes have been cited in the earlier discussion of planning procedures and organizational linkages, and others are in the examination of R&D financing and of the internal human resource and external aspects of R&D management. The moral seems to be that R&D management is more a rich and complex tapestry, characterized by extensive interplay among its elements, than a collection of discrete, neatly compartmentalized tasks.

About Government Programs

Some survey contributors commented on government programs to spur innovations. Among them were spokesmen of firms already involved in such programs. "Cooperation with government to launch new business has always been a strength of our corporation," noted the representative of a chemical company. And an executive of an electronics firm said: "A major segment of the corporation participates in government R&D." In effect, these respondents indicated that their firms would continue, perhaps enlarge, such involvement.

Other participants referred to programs, both specific and general, in which their companies have been and/or would be participating: Allowance for Funds During Construction (applicable to U.S. utilities), ESPRIT (European Strategic Program of Research in Information Technology), development contracts and credits, R&D tax incentives, emission control innovations (cited by a public utility), product development for the Department of Defense, the Ben Franklin Program (sponsored by the Commonwealth of Pennsylvania), and the programs of the National Aeronautics and Space Administration (e.g., communication satellites), the Department of Energy, and the Synthetic Fuels Corporation. Some of these programs, of course, have a financial rather than a technological thrust.

One major U.S.-headquartered multinational corporation appeared to be a reluctant dragon. It will participate in government programs "maybe after three years." A Finnish executive observed that "new governmental programs have not been started" in that country.

Table No. 5: Impact of Technological Change on the Financing of R&D (Responses in Percent)

	Strategic Importance of Change				*Shifts in Impact*		
	In past 12 months		*In next 1-3 years*				
Area of Change	*Major*	*Minor*	*Major*	*Minor*	*Up*	*Down*	*No Shift*
Increases in R&D expenditures related to R&D tax incentives	8	49	12	54	16	3	81
Increases in R&D expenditures relative to other expenditures or fixed investments	20	47	28	50	23	5	72
Absolute increases in capital equipment for R&D people	28	48	40	45	26	6	68
Participation in joint research ventures or partnerships	14	46	26	52	29	2	69

Other changes in funding R&D mentioned were: Creating limited R&D partnerships (cited by three U.S. companies); obtaining funds from venture-capital firms or establishing such firms; licensing of company technology to others; obtaining government grants; doing contract R&D work for government agencies and private companies; crediting the R&D unit with some of the funds flowing from commercialization of its work; providing centralized pools of R&D funds (instead of having each operating unit responsible for R&D expenditures); and sharing R&D expenditures with customers.

Changes in Project-Selection and Evaluation Techniques

Asked to specify changes in project-selection and evaluation techniques flowing from changes in the technological environment, the cooperating executives offered a wide-ranging list that can be grouped in four categories:

Shifts in criteria for evaluation: more emphasis on projects with longer-term payouts; on basic R&D; on new ventures; on projects with better ROI; and on manufacturing technology.

Introduction of new and different procedures: consideration of a greater number of projects; opportunity analysis; adoption of a technical request system; greater use of quantitative techniques; improved procedures for assessing probability of success; better profit-potential forecasting; fuller use of computerized program and project planning and evaluation; different screening and review procedures (both more formal and less formal procedures were mentioned); major changes in procurement methods; portfolio analysis; a larger role for the R&D unit or the senior R&D executive in the project-selection process; more opportunity for the R&D unit to initiate projects; creation of a new research-planning group with responsibilities that include evaluation.

More involvement of others in the organization: mentioned were corporate management; other entities—divisions, operating companies, departments, marketing, corporate planning, the parent company, nontechnical management, business management, peer groups.

More focus on strategy and the market place including, according to one respondent, more emphasis on *new* markets.

Table No. 6: Impact of Technological Change on the Human Resources Aspects of R&D Management (Responses in Percent)

	Strategic Importance of Change				*Shifts in Impact*		
	In past 12 months		*In next 1-3 years*				
Area of Change	*Major*	*Minor*	*Major*	*Minor*	*Up*	*Down*	*No Shift*
Enlargement of the R&D Staff	17	39	19	55	31	11	58
Efforts to improve individual R&D performance	35	54	59	35	31	3	66
Efforts to measure R&D performance more accurately	15	61	35	54	30	1	69
Intensification of training and retraining of R&D employees and/or supervisors	17	56	34	48	26	2	72
Upgrading quality of the R&D staff	33	51	51	39	24	4	72

Other reported externally-oriented changes included: introduction or expansion of efforts to track technologies developed and used outside the company; more intensive monitoring of competitors' R&D programs; closer linkages with customer/suppliers and, where appropriate, companies in the same field; more aggressive licensing ("both ways," said a U.S. manufacturing company executive); deeper involvement in industry-wide programs; and participation in national boards and commissions concerned with R&D.

(text continued from page 8)

grouped by diversity and complexity, significant differences emerged. Single business companies were less likely to have made changes in the past year, and to make changes the next one to three years, in (1) intensification of training and retraining, and (2) upgrading the quality of the R&D staff.

Other Internal Aspects of R&D Management

Neither retrospectively nor prospectively do as many as two-fifths of the companies represented in the survey find technological change altering other aspects of internal R&D management in a major way (see Table 7). The aspect of internal management that garnered the most "major" judgments for the recent past and the future—changes in project selection and evaluation techniques—also elicited more written comments (box, page 11) than any other issue raised in the survey; over 20 percent of the respondents contributed examples of such techniques.

External Aspects of R&D Management

As Table 8 shows, external elements of R&D management have been substantially altered by technological change in comparatively few of the participating companies. For the future, about a third of the firms expect major changes in linkages to universities. (These linkages, and the formation of advisory committees, were also mentioned in connection with other areas of R&D management.)

One of the changes shown at the bottom of Table 8 is more intensive monitoring of competitors' R&D programs. Like the other changes listed there, this one was volunteered by only a handful of respondents, but they considered it a "major" issue. In view of the increasing and recently well-publicized realization of technologically oriented U.S. companies that they need to do a far better job of informing themselves about the progress of their Japanese competitors, one wonders whether this factor may prove to be more important than is now anticipated.

Table No. 7: Impact of Technological Change on Other Internal Aspects of R&D Management (Responses in Percent)

Area of Change	Strategic Importance of Change: In past 12 months — Major	In past 12 months — Minor	In next 1-3 years — Major	In next 1-3 years — Minor	Shifts in Impact: Up	Down	No Shift
Increases in basic and/or applied research compared with product and process development	11	41	22	44	26	6	68
Decreases in basic and/or applied research compared with product and process development	6	29	6	27	5	7	88
Changes in project selection and evaluation techniques	22	50	36	44	28	7	65

Other reported internal R&D management changes in the surveyed firms were: creation of vice president-technology position (two mentions); creation of technical information coordinator to improve application of significant R&D done by industry groups and U.S. government agencies; infusion of market considerations and expertise into R&D planning and evaluation (three mentions); more emphasis on university input; greater use of corporate committees; emphasis on identifying most promising projects and focusing more intently on the chosen few; consolidation of two divisional research organizations; emphasis on newer technology; the bestowal of more freedom to innovate on lower levels of the company; integration of planning for R&D and business planning; and establishment of corporate research-project identification procedures.

Table No. 8: Impact of Technological Change on External Aspects of R&D Management (Responses in Percent)

Area of Change	Strategic Importance of Change: In past 12 months — Major	In past 12 months — Minor	In next 1-3 years — Major	In next 1-3 years — Minor	Shifts in Impact: Up	Down	No Shift
Increases in R&D effort to meet external pressures (e.g., government, consumerism)	17	51	19	54	11	3	86
Formation of an outside science and technology advisory committee to guide R&D	7	18	8	29	17	4	79
Closer company linkages to universities	20	62	34	55	25	4	71

Other reported externally-oriented changes included: introduction or expansion of efforts to track technologies developed and used outside the company; more intensive monitoring of competitors' R&D programs; closer linkages with customer/suppliers and, where appropriate, companies in the same field; more aggressive licensing ("both ways," said a U.S. manufacturing company executive); deeper involvement in industry-wide programs; and participation in national boards and commissions concerned with R&D.